

ANALYSIS OF TRAFFIC ACCIDENT REDUCTION EFFECT BY IMPLEMENTING ROAD SAFETY MEASURES

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ABSTRACT

Recent trends in traffic accidents show that the number of traffic accident fatalities in Japan peaked in 1992 and has declined since that year. The number of traffic accident casualties has tended to fall during the past two or three years, but more than 1 million are injured each year. This is the worst level in history.

In the situation like this, the government has strived to reduce annual number of fatalities who die 24 hours after a traffic accident to 5,500 or less by 2010, in the 8th Fundamental Traffic Safety Program (from FY2006 to FY2010). The government has also strived to reduce the annual number of traffic accident casualties to one million or less by 2010 in the program. The various road safety measures have been being implemented to achieve the goal.

In this Research, We focus the effects of road safety measures implemented by road administrators and analyze it.

As the result, we grasp the effects of road safety measures quantitatively. For example, the reduction effect of head on collision by implementing median strips, the reduction effects of night time traffic accident by installing road lighting and so on.

1. Introduction

Traffic accident fatalities in Japan started to decrease in 1992. In 2008, some 950,000 people were either injured or killed and 5,155 people killed in traffic accidents. The target of annual casualties—less than one million and 5,500 respectively—which the 8th Fundamental Traffic Safety Program attempts to achieve by 2010, was fulfilled two years earlier than targeted (See Fig. 1). Even so, the fact still remains that nearly one million people are injured or killed in traffic accidents every year. Road managers in Japan must reinforce their efforts to reduce traffic accidents.

Our paper presents the effects of individual traffic safety measures and projects conducted to date by road managers and the experimental techniques of quantitatively analyzing the measures conducted at locations where accident reduction efforts have been intensively made—that is, at hazardous spots.

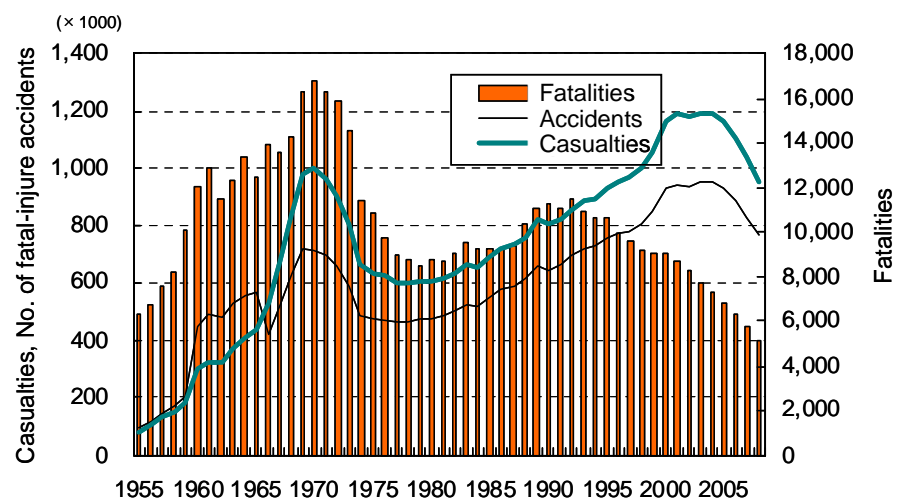


Fig. 1 Traffic accident fatalities in Japan

2. Effects of Traffic Safety Facilities

This chapter deals with the effects of some of the traffic safety facilities, namely median strips and road lighting. The data used are from the road sections of uninterrupted flow of those national highways directly managed by the Minister of Land, Infrastructure, Transport and Tourism (MLIT) and which were improved by implementing traffic safety measures. Specifically, traffic-accident fatalities at locations on those improved road sections where median strips or road lighting were installed and the total length of such sections are used to evaluate the effects of those facilities on accident mitigation.

Fig. 2 shows the total length of the improved road sections, namely those where median strips were installed, and the changes in the death toll in the sections of uninterrupted flow of traffic on those roads, while Fig. 3 shows the changes in the death toll as compared with the deaths in 1996 set as 100. Types of median strip, such as curbstone or guardrail, are ignored in this evaluation. Median strips as long as 397.8 km were constructed from 1996 to 2005 for road improvement, and the death toll in the uninterrupted flow part of those improved sections was reduced from 39 in 1996 to 19 in 2005, a reduction of about 50 percent, and, in terms of head-on collision, from 11 in 1996 to 1 in 2005, a reduction of about 90 percent. The data indicate that construction of the median strips reduced car accident casualties, particularly in head-on collisions, in the road sections of uninterrupted flow.

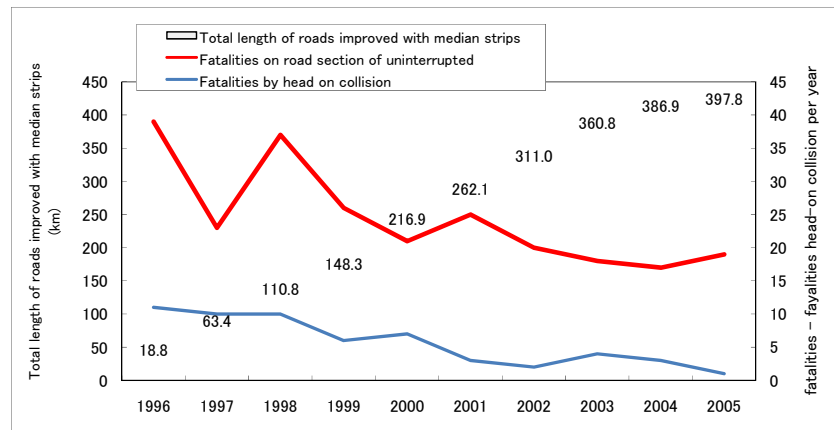


Fig. 2 Cumulative length of roads with median strips and Casualties on uninterrupted flow sections of improved roads

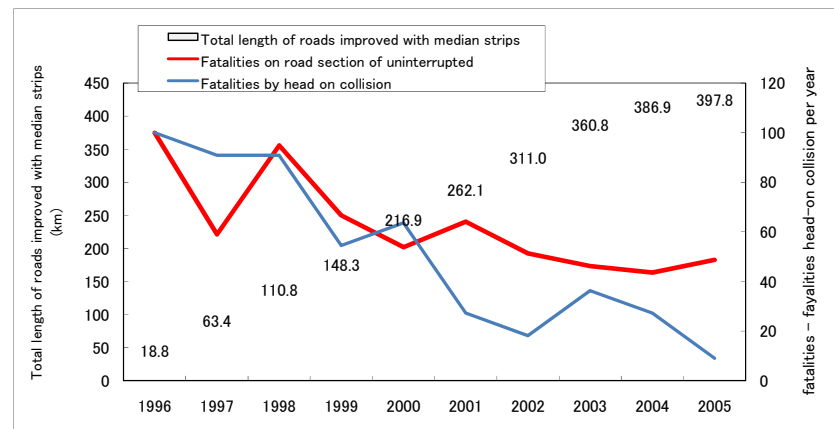


Fig. 3 Cumulative length of roads with median strips and Casualties on uninterrupted flow sections of improved roads

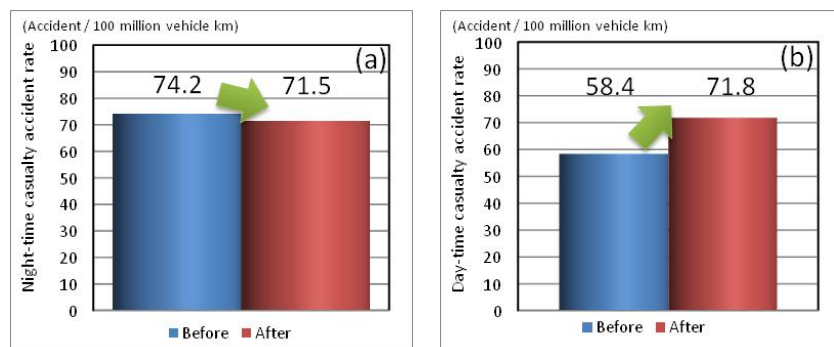


Fig. 4 Casualty accident rate in all types of accident before and after installation of road lighting
(a) Night-time (b) Day-time

Fig. 4 shows the ratio of casualties at night and during the day for all types of accidents before and after

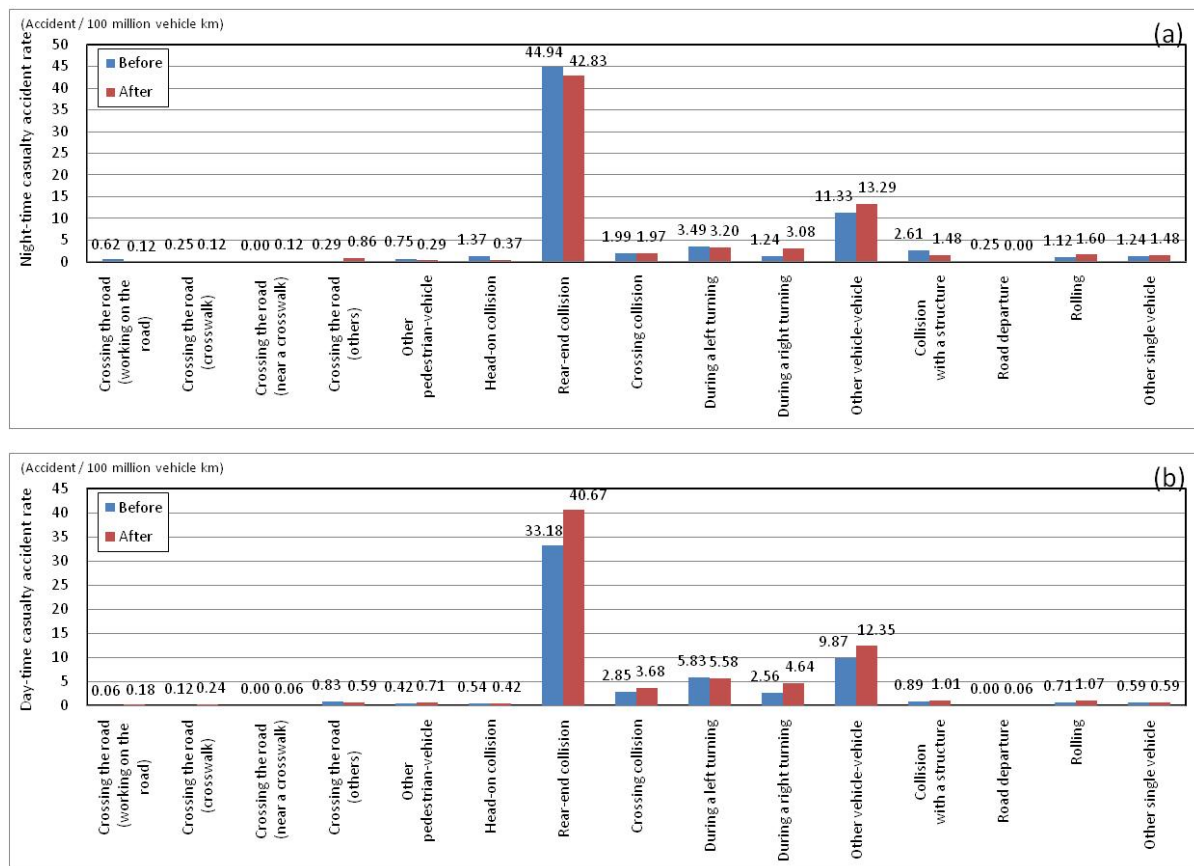


Fig. 5 Casualty accident rate by type of accident before and after installation of road lighting
(a)Night-time (b)Day-time

installation of road lights. Fig. 5 presents graphs, one for night and the other for day, showing changes in the casualty rate by type of accident before and after installation of lighting. The data used are for the road sections of uninterrupted flow where lighting was installed from 1987 to 1993. To calculate the rate of casualty accidents, the data on the number of casualty accidents and the traffic volume for two years each before and after installation of lighting in the years from 1986 to 1994 were used (except for 1987, the year installation of lighting started, and from the year 1993, data are for one year each before and after installation). Taking the locations where lighting was installed in 1990 as an example, the number of casualty accidents and the traffic volume in 1988 and 1989 were used to calculate the accident rate before installation, while those in 1991 and 1992 were used to calculate the rate after installation.

The rate of casualty accidents during the day in the subject sections shows a tendency of increase, while that at night time remains nearly flat. The data, therefore, indicates that the installation of road lights is, in fact, effective in reducing car accidents. By type of accident, the data show a dramatic decrease in the number of crossing the road (others) at night.

3. Emergency Countermeasures Project for High-accident Frequency Locations

Since accidents on arterial roads tend to occur at specific locations, intensive implementation of traffic safety measures at those locations is considered effective. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) selected some 3,200 high-accident frequency locations on arterial roads across the country for the purpose of mitigating a continuing increase in traffic accidents and carried out an Emergency Countermeasures Project for High-accident Frequency Locations. The Project focused on intensive implementation of accident-reduction measures, such as improvement and of intersection installation of road lighting in cooperation with the National Police Agency from the years 1996 to 2002.

The Project includes follow-up surveys after initial implementation of the countermeasures which update the information on how the Project was conducted, what effects the Project had, how many

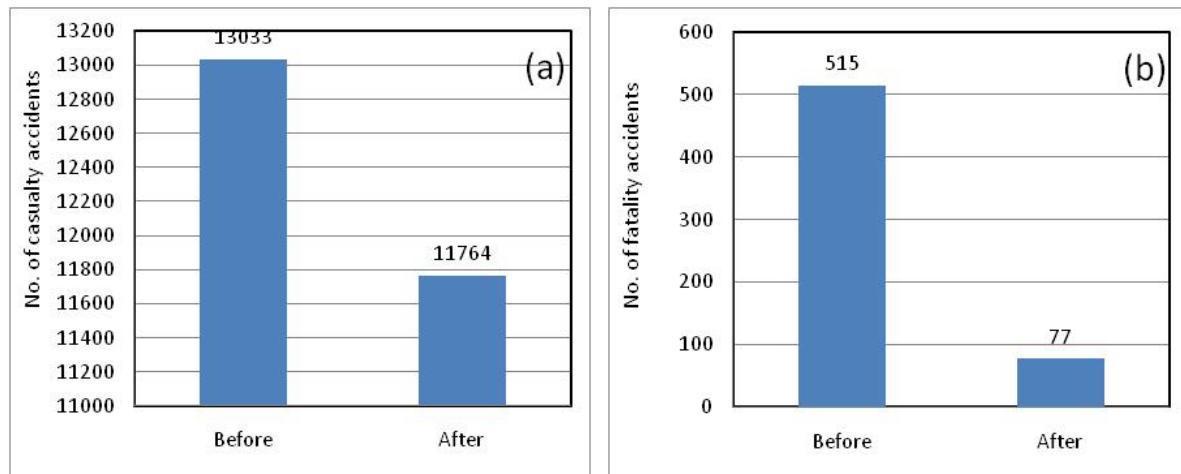


Fig. 6 Accident reduction effect
by the High-accident Frequency Location Countermeasure Project
(a) Casualty accidents (b) Fatality accidents

accidents occurred at each location and how they occurred. We then used the results of the follow-up surveys to calculate the effects of the Project in terms of reduction in the traffic-accident fatalities. Note that since follow-up survey data contain no data on deaths, we estimated the fatalities based on the ratio of the death toll to the number of fatal accidents on arterial roads.

A total of 2,127 locations having a high accident rate, where the measures were almost completed by 2001, were selected for analysis. For the number of accidents before and after Project implementation, the annual average number of accidents from 1990 to 1993 (average over the years from 1990 to 1993) was used for the number of accidents before implementation, while the annual average number of accidents from one year after the year of implementation to 2002 (average over the period of years starting one year after the year of implementation) was used for that after implementation.

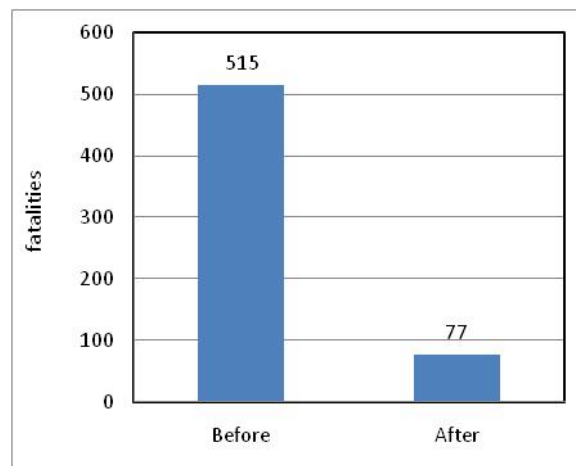


Fig. 7 Fatality reduction effect
by the High-accident Frequency
Location Countermeasure Project

Fig. 6 shows changes in the annual average number of casualty accidents and the number of fatal accidents before and after implementation on the subject road sections. The number of casualty accidents at the Project locations in the year of Project implementation decreased by 1,269, although nationwide the number of such accidents showed a tendency of increase (as shown in Fig. 1). The number of fatal accidents decreased by 438, a decline of about 85 percent.

Fig. 7 is a graph of the annual average fatalities (estimated) by traffic accident on the subject sections before and after Project implementation. The estimation indicates that the decrement in the fatalities is 464 persons.

4. Implementation of Hazardous Spots Project

4.1 Outline of the Project

After termination of the Emergency Countermeasure Project for High-accident frequency Locations in 2002, Implementation of Hazardous Spots Project were conducted from 2003 to 2007.

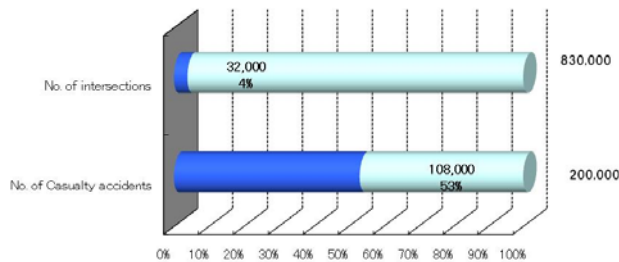
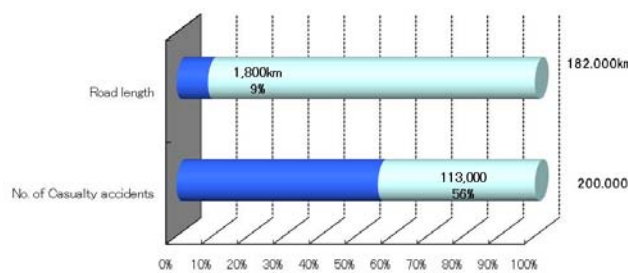


Fig. 8 Ratio of accidents at locations where accidents intensively occur
(a) Road sections of Uninterrupted flow
(b) Intersections

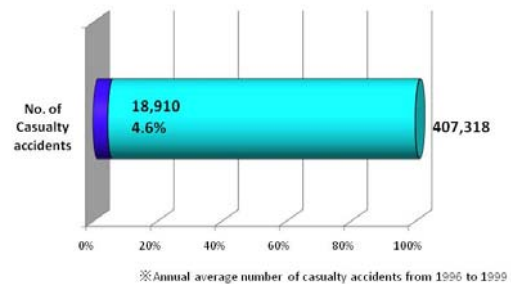


Fig. 9 Ratio of casualty accidents at hazardous spots on arterial road in Japan

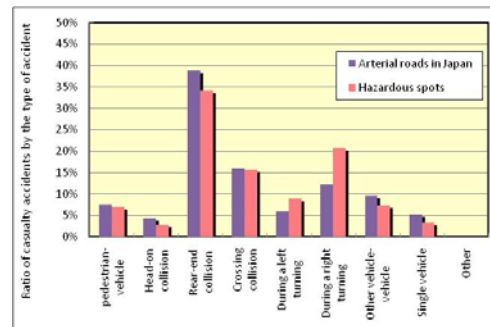


Fig. 10 Ratio of casualty accidents by the type of accident

As mentioned earlier, traffic accidents tend to occur intensively at specific locations. The graphs of Fig. 8 show the ratio of the length of roads or the number of intersections where accidents intensively occur to the total length of arterial roads or the total number of intersections in Japan and the ratio of the number of accidents at locations where accidents intensively occur to the number of accidents on arterial roads in Japan. The data used are the number of casualty accidents occurring from 1998 to 2001. Over half of all casualty accidents occur at 6 percent of the road length for road sections of uninterrupted flow and at 4 percent of all locations for intersections.

For the Implementation of Hazardous Spots Project conducted from 2003 to 2007, some of the locations were selected from the locations where accidents intensively occurred as in the case of the Emergency Countermeasure Project for High-accident Frequency Locations, and traffic safety measures were intensively conducted in cooperation with the National Police Agency. Some 3,956 locations containing 458 km of road sections of uninterrupted flow and 2,717 intersections were selected for such countermeasures. The number of casualty accidents at the selected hazardous spots accounts for about 5 percent of all accidents in Japan (See Fig. 9).

Fig. 10 shows the type-specific ratio of the accidents to all the accidents on arterial roads and at accident-prone locations in Japan before implementation of the measures. The type of accident most frequently occurring on trunk roads in Japan is rear-end collision, followed by crossing collision. For hazardous spots, rear-end collision also ranks at the top, which is, however, followed by during right-turn collision.

4.2 Case Examples of Measures for Specific Locations

This clause outlines the measures taken at specific locations as part of the Implementation of Hazardous Spots Project and their effectiveness.

Fig. 11 is one of the case examples of the Project. The location shown here is a deformed five-forked intersection with a curving main road, or national road, merging with a main local road and a municipal road. As the intersection area is wide and the curvature of the main road is gentle, many vehicles pass through at high speed, the cause of frequently rear-end collisions, accidents involving pedestrian at crossings and accidents at night. The weekday 12-hour traffic volume was 33,933 vehicles.

The solution for this location included the combination of construction of a traffic island and relocation of crossings and stop lines in order to lower the speed of vehicles passing through the intersection, colored-coded paving of the national road surface to clarify the cruising lanes, and installation of road lights to improve night-time visibility.

Fig. 12 compares the annual average number of casualty accidents at this location between with and without a solution. The figure shows the decline in the total number of casualty accidents. Particularly, casualty accidents at night decreased significantly.

Fig. 13 is a different case example for another location. At this location, since a branch line joins the main line at an acute angle, the branch line users suffer poor visibility in the intersection area, which eventually is a cause of a large number of head-on and rear-end collisions. The weekday 12-hour traffic volume was 58,372 vehicles.

The solution provided at this location included changing the intersecting angle of the branch line to a right angle and installing rubber poles.

Fig. 14 compares the annual average number of casualty accidents at this location between with and without the solution. As a result, head-on and rear-end collisions both decreased.

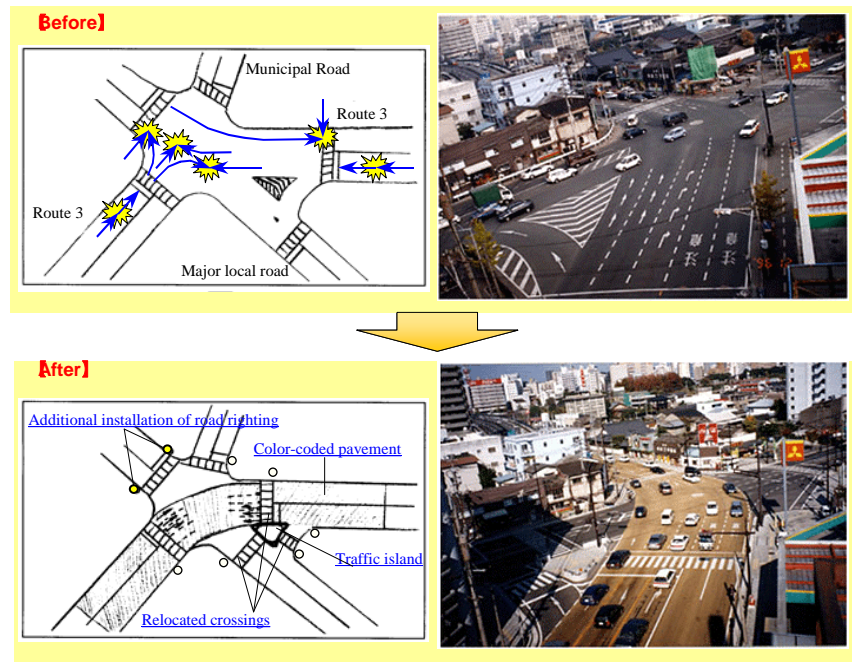


Fig. 11 Case example of accident countermeasure (1)

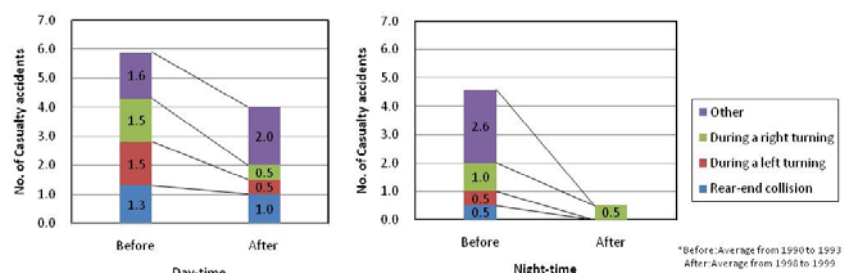


Fig. 12 Effect of accident countermeasure (1)

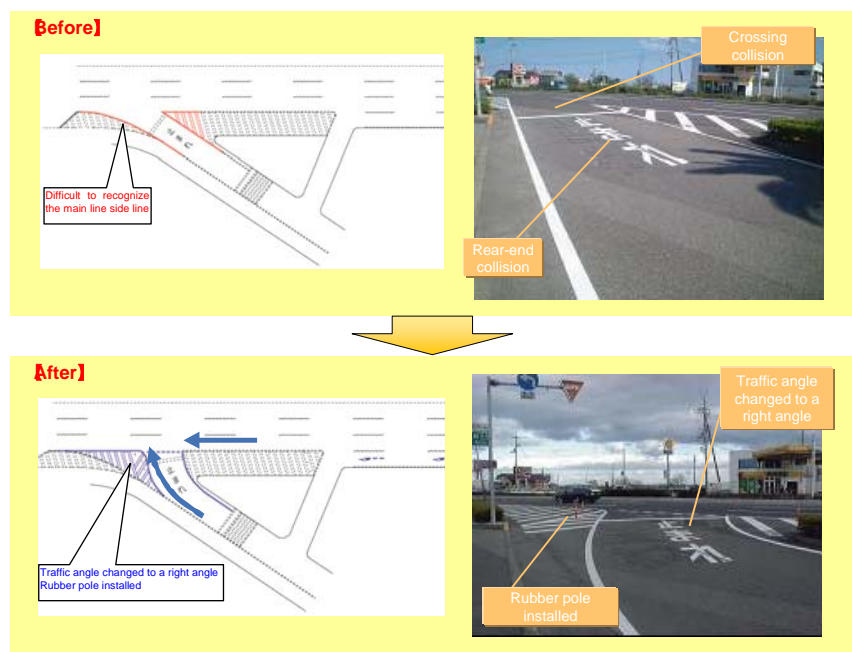


Fig. 13 Case example of accident countermeasure (2)

4.3 Follow-up Survey for Implementation of Hazardous Spots Project

A follow-up survey for hazardous spots is being conducted, which includes monitoring of the traffic accident injuries and deaths. The result of the survey is reported as follows. The survey covers 2,216 locations where the measures were almost completed by 2005.

Fig. 15 compares the number of casualty accidents on arterial roads and hazardous spots in Japan between with and without safety measures. The nationwide number of traffic accident fatalities after implementation increased by about 8 percent from before that. In contrast, there is an about a 19 percent decrease in fatalities, down to 2,047 at hazardous spots with actions taken. Assuming the nationwide tendency applies to those hazardous spots, an 8 percent increase means an increase in accidents to 11,880 at those locations. With this as a reference, the traffic safety measures taken there are judged to be effective in reducing accidents by 25 percent.

Fig. 16 compares the number of fatal accidents at hazardous spots before and after implementation of safety measures. There were 57 fatal accidents, which is about a 52 percent reduction. Fig. 17 compares the traffic accident deaths at the hazardous spots before and after implementation of the measures. There were 84 fatalities, about a 61 percent reduction.

Fig. 18 makes up the accident casualties at the hazardous spots before and after implementation of the measures by the intersection and the road section of uninterrupted flow. A 16 percent reduction, or 1,364 accidents, is recorded for the intersections, while it is a 25 percent reduction, or 683 accidents, at the road section of uninterrupted flow.

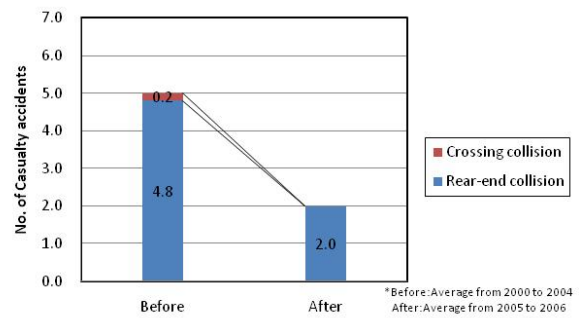


Fig. 14 Effect of accident countermeasure (2)

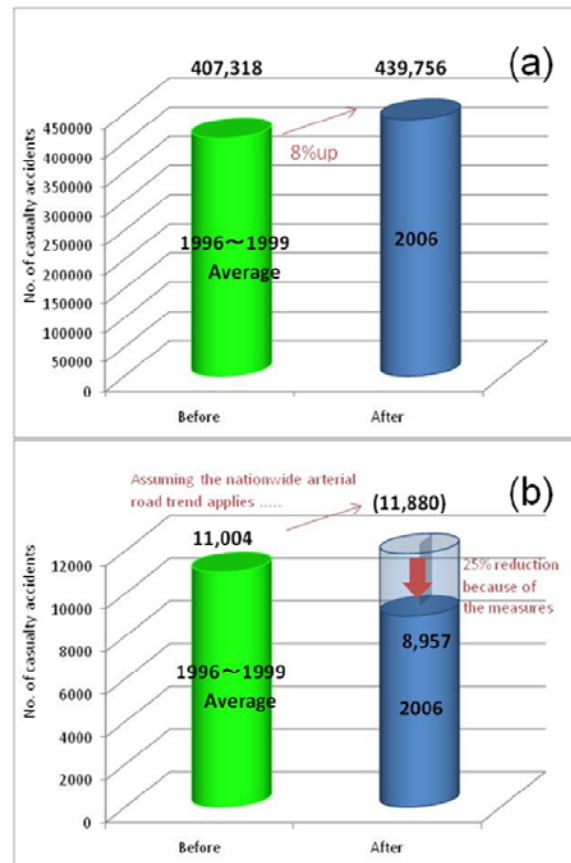


Fig. 15 Accident reduction effect at hazardous spots
(a) Arterial roads in Japan
(b) Hazardous spots

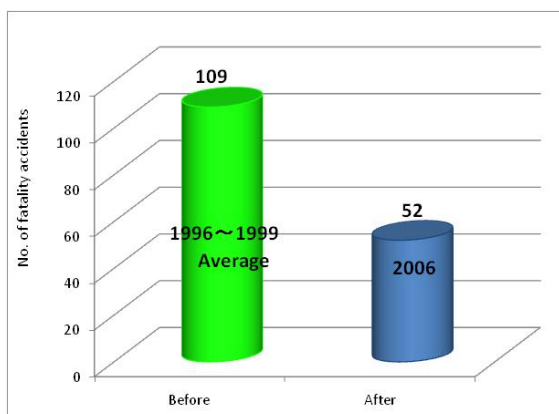


Fig. 16 Fatal accidents at hazardous spots before and after implementation

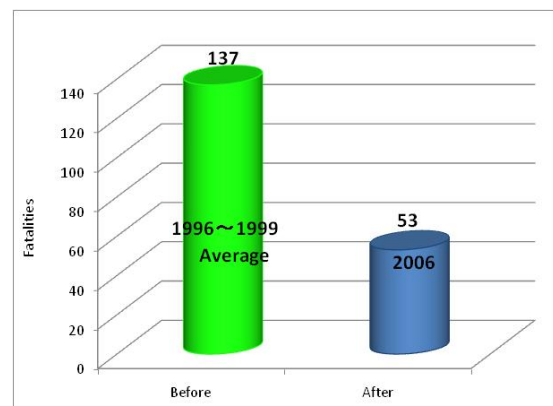


Fig. 17 Fatalities at hazardous spots before and after implementation

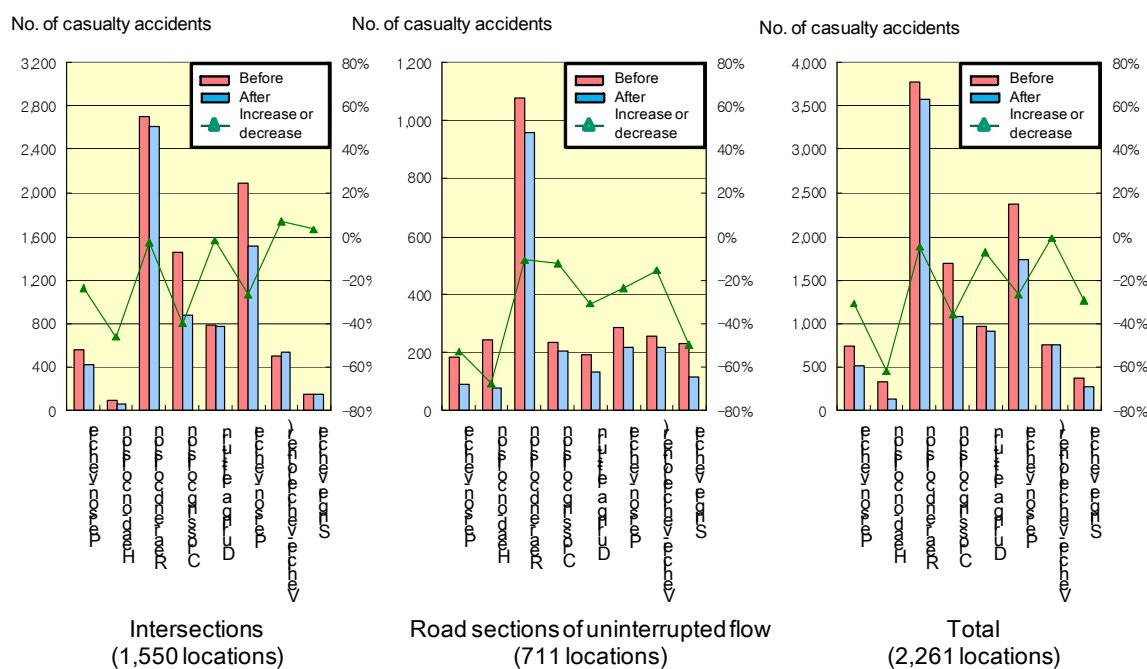
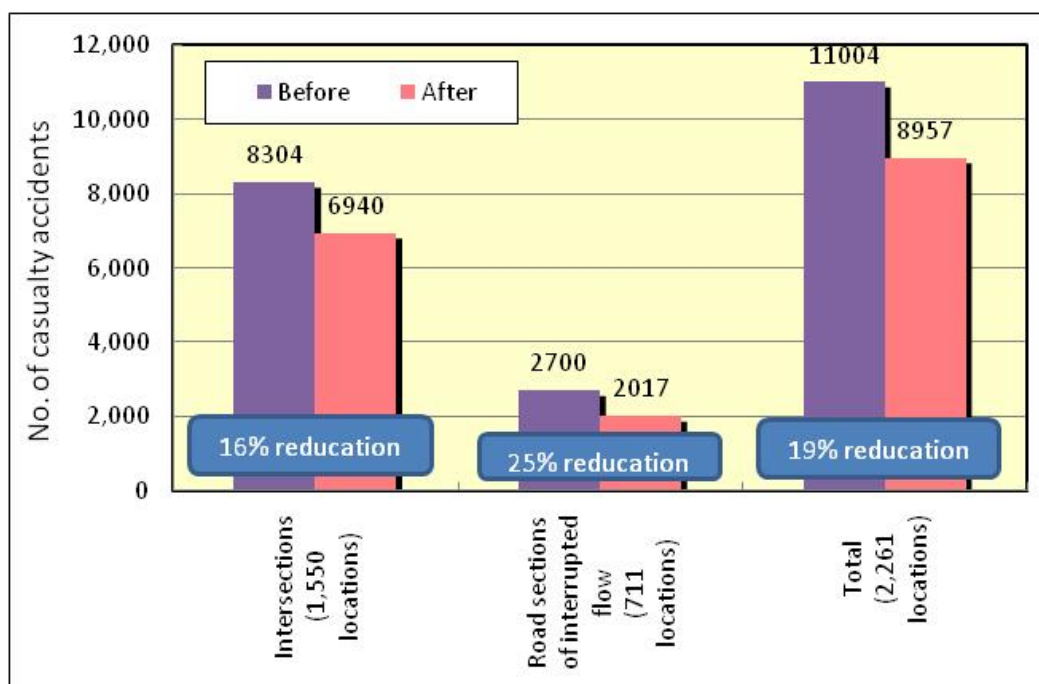


Fig. 19 sums up the results of Fig. 18 by type of accident. This figure indicates that the number of nearly all types of accidents decreased. The reduction ratio of head-on collisions is particularly large either by the intersection or by the road section of uninterrupted flow. Head-on collisions benefit remarkably from the safety measures.

5. Estimation of Basic Units for Accident Reduction Effect

The effect of each type of countermeasure (basic unit for accident reduction effect) was estimated based on follow-up surveys for the Emergency Countermeasure Project for High-accident Frequency Locations, Implementation of Hazardous Spots Project, and other locations where traffic safety measures were taken to provide reference data for development of effective measures best fitting each

type of accident. The basic unit for accident reduction indicates the effect of a single countermeasure on reduction in the number of a single type of accident and is expressed, respectively, by the accident reduction rate.

The method of estimation and the asset conditions used are as follows:

<Method and Conditions of Estimation of Basic Units for Accident Reduction Effect>

(1) Since the purpose is to calculate the effect of a single accident reduction measure, locations where that specific measure was taken should be selected.

(2) Out of those many types of measures, the estimation should be made only for those that were conducted at five or more locations.

(3) The number of accident casualties before and after implementation of measures should be calculated by the location and by the type of accident, and the result for each type of measure should then be added to calculate the total.

(4) The annual average number of casualty accidents in the three years before implementation should be used for the number of casualty accidents before implementation by the type of accident at individual locations, and that in the three years after implementation for the number of casualty accidents after implementation (for locations where implementation of the measures started in less than three years, the currently existing data should be used).

(5) The accident reduction rate by type of measure and by type of accident (the basic unit for accident reduction effect) should be calculated using the number of casualty accidents before and after implementation calculated by the type of measure and by the type of accident (reduction should be expressed as a positive value).

The estimated basic units for accident reduction effect, calculated as above, are shown below:

Table 1 and 2 summarize the basic units for accident reduction on uninterrupted flow sections and at intersections. These tables allow us to see how effective each individual measure is in reducing accidents with respect to the type of accident. Use of the tables also helps us to analyze the current status of accidents at each location and to develop more effective measures.

Those results are provided by only estimation, and so the values are not fully verified by road traffic environmental factors at each location. Therefore, it is necessary to continue review and verification of

Table 1 Basic units for accident reduction (road sections of uninterrupted flow)

Classification	Implementer	Name of measure	No. of location				Casualty accident reduction rate (%)										
			Hazardous spots	Arbitrary registered locations	High-accident frequency locations	Total	Person-vehicle	Vehicle-vehicle						Single vehicle	Others	Total	
								Head-on collision	Rear-end collision	Crossing collision	During a left turning	During a right turning	Other				
Road sections of uninterrupted flow	Road manager	Road lighting	7	0	80	87	57.2%	52.2%	7.2%	-12.8%	22.5%	-95.3%	50.0%	34.0%	-	21.7%	
		Traffic marking	31	0	22	53	45.2%	75.7%	18.3%	-34.1%	-14.2%	-14.6%	-0.7%	54.1%	-	20.3%	
		Delineator	25	0	27	52	36.6%	48.6%	-35.3%	-3.9%	-11.3%	-85.8%	14.5%	32.6%	-	-2.4%	
		Center line, Border line, Near-side line	19	1	21	41	35.3%	39.8%	-1.9%	-26.4%	-35.7%	-31.8%	40.7%	50.3%	-	7.4%	
		Pavement improvement (anti-slip)	8	0	29	37	-7.9%	67.1%	-23.4%	-70.5%	0.2%	-150.4%	34.1%	20.3%	-	-8.6%	
		Sidewalk	6	0	24	30	42.4%	33.5%	-7.9%	-94.3%	-26.5%	-68.8%	25.8%	58.1%	-	-2.2%	
		Median strip	19	0	10	29	31.7%	71.4%	1.7%	-8.9%	-10.8%	-87.2%	13.8%	59.6%	-	5.8%	
		Lane	3	0	20	23	14.6%	62.3%	-16.6%	18.8%	3.2%	13.4%	10.0%	-20.5%	-	0.2%	
		Warning sign	5	0	17	22	57.6%	65.6%	-9.7%	-103.0%	-33.3%	-49.1%	38.0%	62.1%	-	12.8%	
		Improvement of planting zone	9	0	7	16	72.3%	40.5%	-49.6%	-5.7%	-16.4%	-326.7%	8.1%	64.6%	-	-20.3%	
		Bypass	3	0	13	16	68.7%	75.8%	71.4%	-4.8%	66.7%	-233.3%	14.4%	41.1%	-	51.4%	
		Alignmentimprovement	1	0	8	9	23.8%	35.7%	-8.7%	-37.0%	-91.1%	-2.3%	2.2%	10.0%	-	-8.9%	
		Guardrail for sidewalk	1	0	8	9	-4.1%	26.7%	-46.5%	-157.3%	-50.8%	-82.4%	-19.1%	-13.3%	-	-40.0%	
		Guide sign	1	0	6	7	0.0%	68.6%	-1.8%	-190.7%	-113.3%	-72.1%	-4.9%	53.8%	-	-2.3%	
	Public Safety Commission	Traffic sine and roadmarking	18	0	14	32	41.1%	74.9%	-12.4%	-4.2%	7.3%	0.9%	9.7%	57.5%	-	10.9%	
		Installation of traffic signal	8	0	4	12	48.4%	49.1%	17.9%	-14.2%	57.3%	2.5%	3.0%	50.1%	-	21.9%	
		Traffic control (related to vehicles)	6	0	5	11	45.1%	60.0%	-22.1%	27.3%	0.5%	-40.7%	38.9%	43.3%	-	0.2%	
		Pedestrian and bicycle crossing	3	0	3	6	73.7%	-133.3%	27.4%	38.5%	-300.0%	-47.6%	23.3%	75.8%	-	30.1%	
Improvement of traffic signal		4	0	1	5	87.9%	100.0%	36.8%	84.1%	-66.7%	27.3%	100.0%	60.0%	-	59.7%		

Table 2 Basic units for accident reduction (intersections)

Classification	Implementer	Name of measure	No. of location				Casualty accident reduction rate (%)										
			Hazardous spots	Arbitrary registered locations	High-accident frequency locations	Total	Person-vehicle	Vehicle-vehicle						Other	Single vehicle	Others	Total
								Head-on collision	Rear-end collision	Crossing collision	During a left turning	During a right turning					
Intersections	Road manager	Traffic marking	87	2	27	116	16.4%	54.4%	15.3%	44.1%	-2.9%	23.9%	-12.3%	-59.3%	-	20.7%	
		Right-turn Lane	55	2	33	90	30.5%	68.0%	-13.8%	35.1%	22.8%	24.8%	25.4%	15.8%	-	15.7%	
		Road lighting	28	2	56	86	36.8%	62.5%	21.4%	39.3%	22.4%	12.9%	23.1%	51.9%	-	26.4%	
		Improvement of intersection	46	0	33	79	20.5%	7.0%	-25.8%	32.9%	-28.5%	-5.1%	9.3%	-10.1%	-	-2.6%	
		Pavement improvement (colored paving)	18	0	6	24	53.8%	-322.2%	-5.3%	42.6%	-2.4%	57.7%	-71.4%	46.7%	-	22.8%	
		Pavement improvement (anti-slip treatment)	7	0	14	21	15.9%	-3.3%	13.3%	72.1%	23.2%	48.7%	11.7%	57.6%	-	32.4%	
		Improvement of planting zone	15	0	3	18	17.3%	100.0%	33.1%	28.7%	-63.9%	34.3%	-107.1%	71.4%	-	17.8%	
		Pavement improvement (porous pavement)	15	1	x	16	-116.7%	100.0%	41.3%	100.0%	4.8%	50.5%	-6.7%	-	-	40.2%	
		Channelizing strip	9	1	5	15	50.3%	80.0%	25.2%	39.4%	-14.4%	11.4%	-8.4%	81.9%	-	22.6%	
		Warning sign	9	0	5	14	74.3%	0.0%	-32.3%	65.6%	-14.3%	9.3%	26.1%	-33.3%	-	20.0%	
		Median strip (front end marking)	5	0	6	11	30.3%	81.0%	43.9%	70.0%	34.9%	45.4%	16.2%	46.0%	-	43.5%	
		Sidewalk	9	0	0	9	-33.3%	-	21.2%	74.1%	-10.1%	65.9%	-33.3%	-	-	30.2%	
		Guardrail for sidewalk	4	0	5	9	15.7%	100.0%	-0.4%	25.3%	5.6%	0.6%	-10.0%	-44.4%	-	6.0%	
		Grade crossing	0	0	7	7	54.4%	43.3%	-13.6%	55.0%	-7.5%	57.2%	35.8%	4.0%	-	28.0%	
	Guide sign	2	0	4	6	26.7%	100.0%	-63.9%	28.6%	-76.2%	-13.8%	18.3%	-83.3%	-	-15.6%		
	Left-turn lane	2	1	2	5	-31.1%	100.0%	-31.1%	7.1%	10.5%	23.6%	17.5%	100.0%	-	-0.3%		
	Public Safety Commission																
		Improvement of traffic signal	101	1	10	112	13.0%	59.1%	-2.6%	19.4%	-41.6%	24.2%	-33.9%	-23.1%	-	2.6%	
		Improvement of signal phase	43	0	36	79	27.1%	35.3%	-28.5%	40.1%	-43.0%	13.6%	5.4%	22.4%	-	3.7%	
		Traffic sign and road marking	48	1	8	57	39.5%	55.6%	-10.6%	10.0%	22.6%	34.2%	-5.1%	37.9%	-	13.1%	
		Installation of traffic signal	31	0	1	32	18.7%	55.6%	-9.2%	58.8%	-50.0%	33.3%	27.8%	-500.0%	-	25.8%	
		Installation of traffic signal	10	0	4	14	28.2%	100.0%	-13.9%	22.4%	-124.1%	15.0%	29.9%	71.4%	-	3.8%	
		Traffic control (related to vehicles)	10	0	2	12	-16.3%	-	-23.1%	34.1%	-33.3%	17.8%	34.7%	4.0%	-	8.9%	

the effects of the traffic safety measures on reduction of accidents and apply the outcome to analysis of accident reduction measures.

6. Conclusion

We analyzed the currently stored accident data and the historical data of traffic accident reduction measures conducted by road managers and revealed the following findings:

- (1) Construction of a median strip reduces the fatalities in an road section of uninterrupted flow. The reduction effect is particularly high for head-on collisions.
- (2) Installation of lighting reduces accidents at night.
- (3) Implementation of emergency countermeasures for high-accident frequency locations reduces injury accidents and accidents with fatalities, which indicates the effectiveness of the measures in reducing overall accidents.
- (4) Follow-up surveys for hazardous spot countermeasures clarify that countermeasures are significantly effective in reducing accidents at the locations where they were conducted.
- (5) Hazardous spot location countermeasures are significantly effective in reducing accidents on uninterrupted flow sections and particularly help to significantly reduce head-on collisions.

As explained above, traffic safety measures taken by road managers are shown to help reduce traffic accidents. Even so, the fact remains that nearly one million people are killed or injured by traffic accidents every year. More efficient and effective measures are necessary from now.

The basic units for accident reduction estimated in this paper allow us to see how effective each specific accident reduction measure is and in what way it is effective and may provide us with indicators that help conduct more efficient and effective accident reduction measures.